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REPORT

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SKYLAB EXPERIMENT PERFORMANCE EVALUATION MANUAL

Appendix P: Experiment T003 Inflight Aerosol Analysis (DOT/MSFC)

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Prepared for

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16. ABSTRACT

This appendix contains a series of analyses for Experiment T003, Inflight Aerosol Analysis (DOT/MSFC), to be used for evaluating the performance of the Skylab corollary experiments under preflight, inflight, and post-flight conditions. Experiment contingency plan workaround procedure and malfunction analyses are presented in order to assist in making the experiment operationally successful.

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DEFINITION OF SYMBOLS

AA	Aerosol Analyzer
AM	Airlock Module
CM	Command Module
FBD	Functional Block Diagram
FO	Functional Objective
OA	Orbital Assembly
OWS	Orbital Workshop
PI	Principal Investigator
PMT	Photomultiplier Tube
P_f	Probability of Failure
P_{f_t}	Total Probability of Failure
P_s	Probability of Success

SECTION I.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS

TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 1 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER*	REMARKS
	MIN.	NOM.	MAX.		
3.0 Analyze and predict facet Performance Profiles for Skylab Experiment T-003, In-flight Aerosol Analysis.				N/A	Refer to functional item 3.1.
3.1 Make explicit statements about objectives in qualitative and quantitative terms.				N/A	Refer to functional item 3.1.1.
3.1.1 Specify the time required for T-003 tasks to be performed.					Crew time is the time required to set up, perform, and stow Experiment T-003. Reference 1.
• SL-1/SL-2 Mission		hr:min			
--Crew time					
--Setup					
--Operation		11:48			
--Stowage		00:06			
• SL-3 Mission					
--Crew time					
--Setup					
--Operation		25:30			
--Stowage		00:06			
• SL-4 Mission					
--Crew time					
--Setup					
--Operation		26:15			
--Stowage		00:06			
3.1.2 Specify the criteria that are to be maximized or minimized.				N/A	The functional objectives (FO) of Experiment T-003 are: • FO-1: As soon as practical (no later than 5 days after OWS activation), the experiment will be performed in the following areas: --CS-E (experiment compartment near the ceiling). --CS-D The measurement is to be taken at the center of the hatch between the Airlock Module (AM) and the Orbital Workshop (OWS) in the forward dome area. --CS-CM Command Module (CM) center couch. --CS-E Crew quarters near air diffuser. --CS-W (Wardroom above the table). The measurement is to be taken immediately

*Criticality Category Number Definition:

- Category I--Experiment and equipment whose failure could adversely affect crew safety.
- Category II--Experiment and equipment whose failure could result in not achieving a primary mission objective, but does not adversely affect crew safety.
- Category IIIa--Experiment and equipment whose failure could result in not achieving a secondary mission objective, but which does not adversely affect crew safety or preclude the achievement of any primary mission objective.
- Category IIIb--Experiment and equipment whose failure could not result in a loss of primary or secondary mission objectives and does not adversely affect crew safety.

TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 2 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3. 1. 2 (Concluded)					before food preparation and immediately after eating. --CS-H (Waste Management Area). The measurement is taken at the intercom wall. The measurement will be made immediately before use of the facility and after weighing of the wet fecal sample bag. (Experiment M-071 mineral balance). --CS-F Forward Compartment (area where the astronaut changes clothes). The measurements will be made immediately after scheduled or normal changing or donning of clothing. Note: Subsequent readings at Crew Station E (near ceiling) will be taken every 8 ±2 hr thereafter. • FO-2: Every 10 days (after initial measurements) Aerosol Analyzer (AA) readings will be taken at CS-D, CS-CM, CS-E (near the air diffuser) immediately after the regularly scheduled 8 ±2 hr readings at CS-E (near the ceiling). • FO-3: Every 10 days (after the initial measurements) AA readings will be taken at the following stations: --CS-W Take readings before food preparation and after the meal. --CS-H Take readings before use of the sanitary facility and after weighing of the wet sample fecal bag. --CS-F Take readings immediately after changing or donning suit. • FO-4: At the astronaut's dicretion, up to 20 readings will be made during the flight at times and positions that the astronaut feels may be a source of particle generation. References 1, 2, 3, and 4.
3. 1. 3 Specify the percentage of acceptable max. /min. for each criterion.				N/A	It is subjectively estimated that accomplishment of the following would provide a minimum acceptable amount of experimental data:
	40%	50%	60%		• FO-1: Conduct two performances per day for 24 days. This constitutes 66.6% of the desired performance or 40% of the total objective.
	10%	12.5%	15%		• FO-2: Conduct two performances once every 10 days. This constitutes 66.6% of the desired performances, or 10% of the total objective.
	10%	12.5%	15%		• FO-3: Conduct two performances once every 10 days. This constitutes 66.6% of the desired performances, or 10% of the total objective.
	7.5%	8.75%	10%		• FO-4: Take at least 15 readings at the astronaut's discretion. This constitutes 75% of the desired readings or 7.5% of the total objective.
	67.5%	83.75%	100%		Total percentage of acceptable max. /min.

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TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 3 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.1.4 Specify the experiment constraints and operational tolerances. • Musts • Must Nots • Wants • Don't Wants.				N/A	• Musts --The operator must keep his movements to a minimum during the performance of the experiment --Air inlet of AA must be pointed perpendicular to the spacecraft longitudinal axis. • Must Nots --N/A • Wants --N/A • Don't Wants --N/A References 5 and 6.
3.1.5 Specify experiment operational tolerances. • Musts • Must Nots • Wants • Don't Wants.				N/A	Refer to functional item 3.1.4.
3.2 Define decision rules and success criteria for the experiment objectives.				N/A	If the experiment is aborted, then the probability of success (P_s) is equal to 0.0. If the experiment is compromised and minimum information is salvaged, $P_s = 0.1 \rightarrow 0.5$; if the maximum information is salvaged, $P_s = 0.5 \rightarrow 0.9$. If the experiment is completed as scheduled, $P_s = 1.0$.
3.3 Specify the experiment priority (numerical statement) for a given Skylab flight designation.				N/A	Experiment T-003 is scheduled for SL-1/SL-2, SL-3 and SL-4 Missions. The priority number is 400. Reference 7.
3.4 Briefly describe and list the major subsystems for Experiment T-003.				N/A	Refer to functional items 3.4.1 and 3.4.2.

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TABLE P-1. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 4 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.4.1 Describe the major functions.				N/A	Experiment T-003 is designed to measure the concentration and the size distribution of particles suspended in the air (aerosol particles) in the OWS. The data obtained from this experiment will be used in assessing the following: • Generation of particle matter by crew members and spacecraft components. • Adequacy of air distribution, circulation, and filtration inside the OWS. • Effects of zero-gravity on the buildup and distribution of particles. • Establishment of an index for habitability and allowable aerosol levels inside the spacecraft. References 5 and 6.
3.4.2 List the major components.				N/A	The major components of Experiment T-003 are: • Pneumatic subsystem • Optical subsystem • Filter impactor unit • Electronic/electrical subsystem. References 5 and 6.
3.5 Define the T-003 experiment/carrier subsystem interfaces: • Physical --Mechanical --Electrical --Communication and Data --Support • Environmental --Natural and Induced --Contamination • Operational --Pointing and Control --Crew Safety --Sequence --Operability.				N/A	A Functional Block Diagram (FBD) is submitted as Figure P-1 and is used as a subsystem component listing. Critical subsystem components will be identified and evaluated for failure and correlated to possible experiment/carrier interface problems.

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TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 5 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3. 5. 1 Filter Assembly				N/A	Refer to functional item 3. 5. 1. 1.
3. 5. 1. 1 Specify the total probability of failure (P_{f_t}) for the filter insert.		0. 1		IIIb	The filter insert consists of eight impactor discs and a silver membrane filter. The filter unit is inserted into the housing at the front of the AA. The filter has eight settings for the different OWS measurement stations. The filter insert is designed to be easily removed by pulling it out when the keeper pin is aligned with a slot. The OWS air is pumped through the AA. An optical subsystem detects and counts the particle matter in the air sample according to size and range. The air then passes through the filter. The particles larger than 1 micron are impacted onto the nickle disc and retained. Smaller particles lack inertia and are trapped by a silver membrane filter. At the end of each measurement, the filter is indexed to the next designated number and the measurements are taken as required. One filter impactor is required for each mission. The filter impactor is removed from the AA at the end of each mission and returned to the Principal Investigator (PI) for further analysis. The probability of failure (P_f) of the filter unit is considered to be small. If this were to fail, the following could occur: • Mechanical --If the filter is clogged, it impedes or stops the airflow, and could invalidate the particle count and eventually damage the pump or motor. --Filter rupture would degrade the optical performance. --If the filter insert cannot be indexed, it will be impossible to determine the location of the performance and will result in loss of particle composition. --If the filter cannot be removed, it may result in loss of revisit potential usage. --If the filter cannot be inserted, it will result in loss of particle composition/ spacecraft relationship. The following indications could be used to determine the failure of the filter insert: • Tight rotation of the filter insert is an indication that the O-ring seals are damaged. • Weak exhaust air could be an indication that the filter is clogged (restricting the airflow through it). • If large particles are found in the exhaust air, it is an indication that the filter membrane has ruptured. References 8 and 9.

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TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 6 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.2.1 Specify the P_{f_t} for the dc motor.		nil		IIIb	The brushless dc motor drives the pneumatic pump of the AA. The motor is coupled to the pump by a connecting rod. The motor requires 12 V to operate it, and the power is supplied by six silver zinc batteries rated at 1.9 Vdc each. The P_f of the motor is considered remote. If the motor were to fail, the following situation could occur: • Electrical --Grounding, shorting, or any other malfunction would prevent the operation of the pump, thereby precluding the experiment. The following indication can be used to determine the failure of the motor: • If no operating noise of the pump is heard when the switch is turned on, it is an indication that the motor is not operating. • No exhaust air is felt at the exhaust.
3.5.2.3.1.1 Specify the P_{f_t} for the connecting rod bearing.		0.1		IIIb	The bearing is mounted on the motor shaft. The bearing is a ball bearing type, double sealad, and made of stainless steel. The bearing is lubricated with EI Dupont Krytox PR 240 AC grease. The P_f of this bearing is considered to be very small. If the bearing were to fail, the following situation could occur: • Mechanical --The pump could fail to operate due to bearing failure. The following indication could be used to determine the failure of the bearings. • A distinct vibration noise. Reference 9.
3.5.2.3.2 Specify the P_{f_t} for the flap valve.		0.1		IIIb	This valve is a part of the diaphragm pump assembly. It allows the air to pass through in one direction. It is estimated that the P_f of this valve will be very small. If the valve should fail, the following could happen: • Mechanical --If the valve is closed during the upward stroke of the connecting rod, it could damage the diaphragm.

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TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 7 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.2.3.2 (Concluded)					--If the valve remains open at all times, the pump will not be able to supply air necessary to operate the experiment. The following indication could be used to determine the failure of the valve: • There are no cues available to determine the failure of the valve. Reference 9.
3.5.2.3.3 Specify the P_{f_t} for the diaphragm.		0.1		IIIb	The diaphragm is a part of the pump and is attached to the connecting rod. The P_f of the diaphragm is very small. If the diaphragm should fail, the following could occur: • Mechanical --A ruptured diaphragm would result in complete failure of the experiment. The following indication could be used to determine the failure of the pump: • No air suction felt at the inlet could indicate that the diaphragm is ruptured. References 8 and 9.
3.5.3.1 Electrical subsystem.				N/A	Refer to functional item 3.5.3.1.1.
3.5.3.1.1. Specify the P_{f_t} for the power converter.		nil		IIIb	The power converter converts regulated 5 to 12 V needed for the operation of the diaphragm pump electric motor and 6 V for the logic circuits. It is estimated that the P_f of the converter is very small. If it should fail the following situation could occur: • Electrical --Grounding, shorting, or any other electrical malfunction preventing the output from the converter would result in subsystem and possible system failure. This will cause a total failure of the experiment. The following indication could be used to determine the failure of the power converter: • Refer to applicable paragraph under functional item 3.5.2.1. Reference 10.

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TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 8 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.3.1.2 Specify the P_{f_t} for the high voltage supply and doubler.		nil		IIIb	The high voltage supply and doubler supplies power to the photomultiplier tube (PMT). The P_f for the PMT is considered to be remote. If this were to fail the following situation could occur: • Electrical --Failure of the high voltage and doubler to operate would result in complete loss of experiment. --Lack of regulation voltage would result in loss of the experiment. There is no visual or any other means to determine that the high voltage supply and doubler has failed. References 8 and 10.
3.5.3.1.3 Specify the P_{f_t} for the battery pack.		0.1		IIIb	The batteries are the main source of power supply to the T-003 experiment. The pack contains six yardney silver zinc batteries rated at 11.8 Vdc. The batteries are capable of supporting 385 operations of 94 sec each. The batteries are designed to last for all three Skylab missions. The no load voltage of the battery pack is 11.2 $\pm$ 0.2 Vdc. It is estimated that the P_f of the batteries is considered to be very small. If these were to fail the following situation could occur: • Electrical --Loss of battery will result in premature termination of the experiment. The following indication could be used to determine the failure of the batteries: • Digital displays are not illuminated. No airflow when the switch is turned ON. References 8, 9, and 10.
3.5.3.2.1.2 Specify the P_{f_t} for the timing generator.		0.1		IIIb	The timing generator is a device designed to combine 2 Hz clock input pulses to generate required timing pulses. It is estimated that the P_f of the timing generator is considered to be very small. If it were to fail the following situation could occur: • Electrical --Failure of the logic circuit to function normally could cause the pump motor to turn off prematurely. This will result in complete loss of the experiment.

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TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 9 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.3.2.1.2 (Concluded)					The following indication can be used to determine the failure of the timing generator: • If the motor shuts off sooner than 70 sec after initiation sequence switch on, it could be an indication of failure of timing generator logic circuit. Reference 8.
3.5.3.2.1.3 Specify the P_{f_t} for the pulse height coder.		0.1		IIIb	The pulse height coder logic codes particle size information. A pulse on one of the channels indicates the particle size range. The P_f of the pulse height coder is considered to be very small. If these were to fail the following situation could occur: • Electrical --Erratic operation of logic would give erroneous information and may result in partial loss of the experiment. --Failure of the logic to operate may result in loss of the experiment. The following indication could be used to determine the failure of pulse height coder : • Failure to register on the digital display in any one of the channels may be an indication that a component has failed in the pulse height coder logic circuit. References 8 and 9.
3.5.3.2.1.5 Specify the P_{f_t} for the decade counters.		0.1		IIIb	The counters will receive their pulses from the pulse height coders and store the information of the particle count for each channel. The P_f of this component is considered to be very small. If this were to fail the following could occur: • Electrical --An open circuit in any of the decade counters would result in a failure of one, two or three of the channels. The following indication could be used to determine the failure of decade counters: • Refer to appropriate paragraph of functional item 3.5.3.2.1.3. References 8 and 9.

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TABLE P-I. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 10 of 10)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.3.2.2.2 Specify the P_{f_t} for the pilot/overflow lamp.		0.1		IIIb	The pilot/overflow lamp has two functions. The lamp is turned on when the "Initiation Switch" is activated; indicating that the experiment is in operation. The lamp will go off after a certain time. It lights again during the display phase when the displayed channel's counting has exceeded 9,999 particles. It is estimated that the P_f of this lamp is very small. If this were to fail the following situation could occur: • Electrical --This may cause the crewman to question whether the experiment is on. It could also result in an invalid reading if the particle overflow has occurred. This may result in partial loss of the experiment. The following indication can be used to determine the failure of the pilot/overflow lamp: • The failure can be determined by astronaut observation. References 8, 9, and 10.
3.5.4.4 Specify the P_{f_t} for the photomultiplier tube (PMT).		nil		IIIb	The PMT is a part of the optical subsystem. It detects the scattered light and converts amplitude proportional to electrical signal. The P_f of the PMT is considered to be very small. If it fails the following situation could occur: • Electrical --If any PMT component fails, the PMT will not convert the scattered to electrical impulses and the result will be a complete loss of the experiment. The following indication could be used to determine the failure of the PMT: • The digital readout count will read zero on all of the three channels. References 8, 9, and 10.

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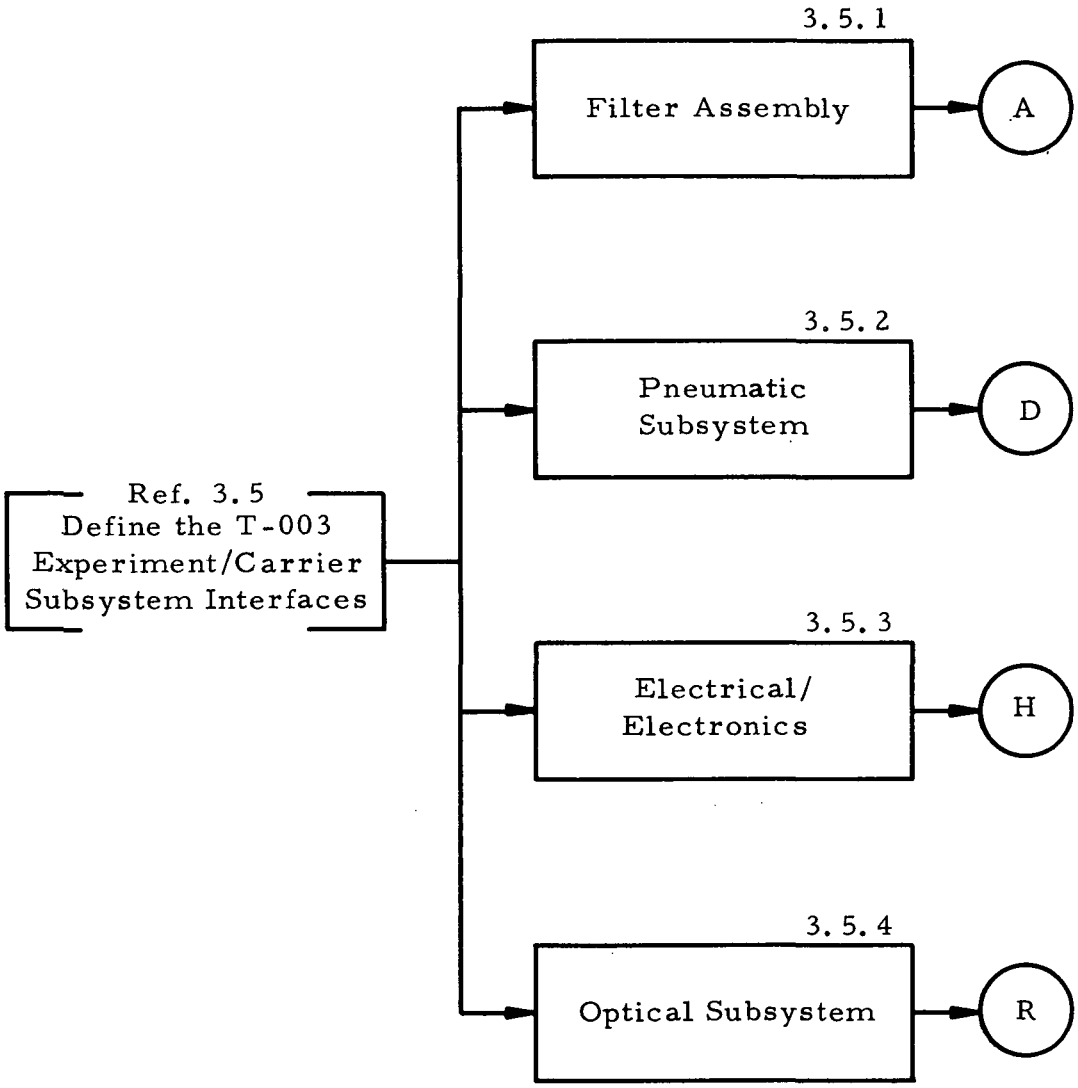


FIGURE P-1. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS FUNCTIONAL BLOCK DIAGRAM (Sheet 1 of 6)

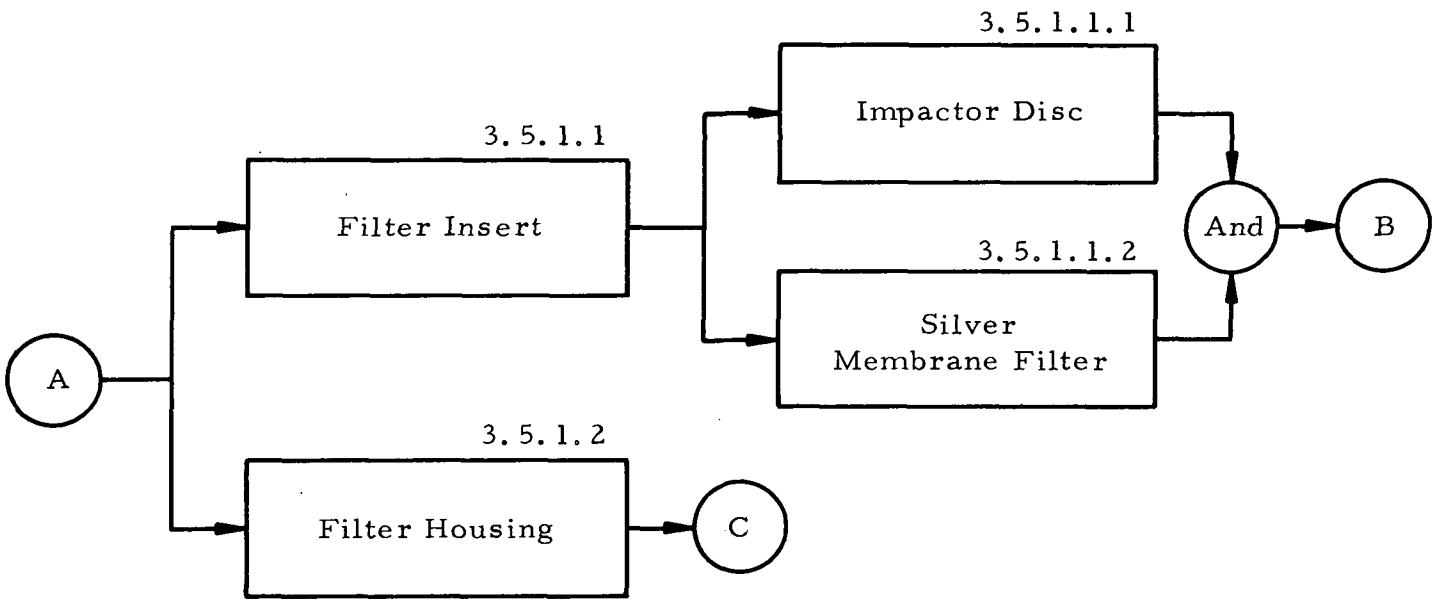


FIGURE P-1. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS FUNCTIONAL BLOCK DIAGRAM (Sheet 2 of 6)

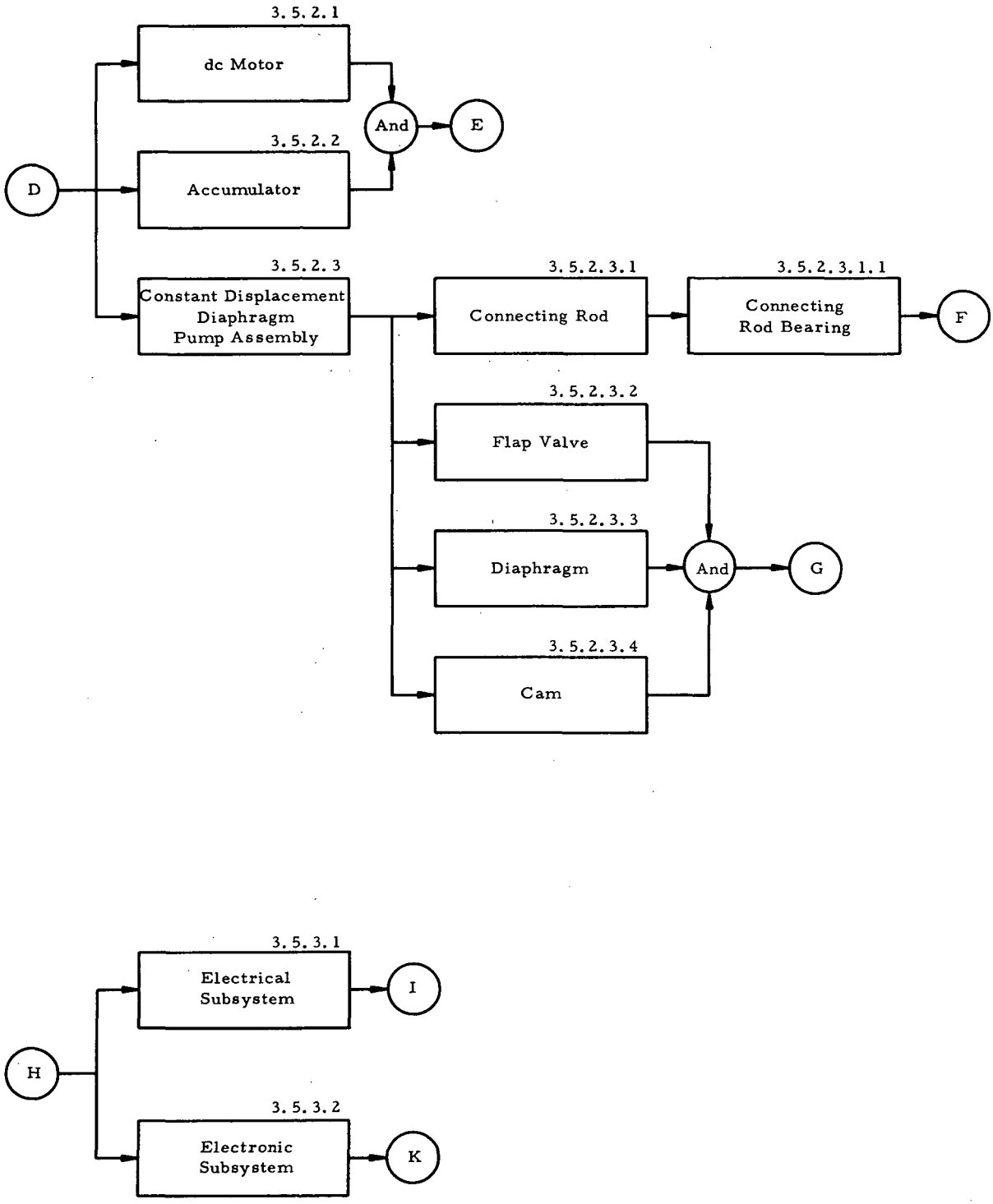


FIGURE P-1. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS FUNCTIONAL BLOCK DIAGRAM (Sheet 3 of 6)

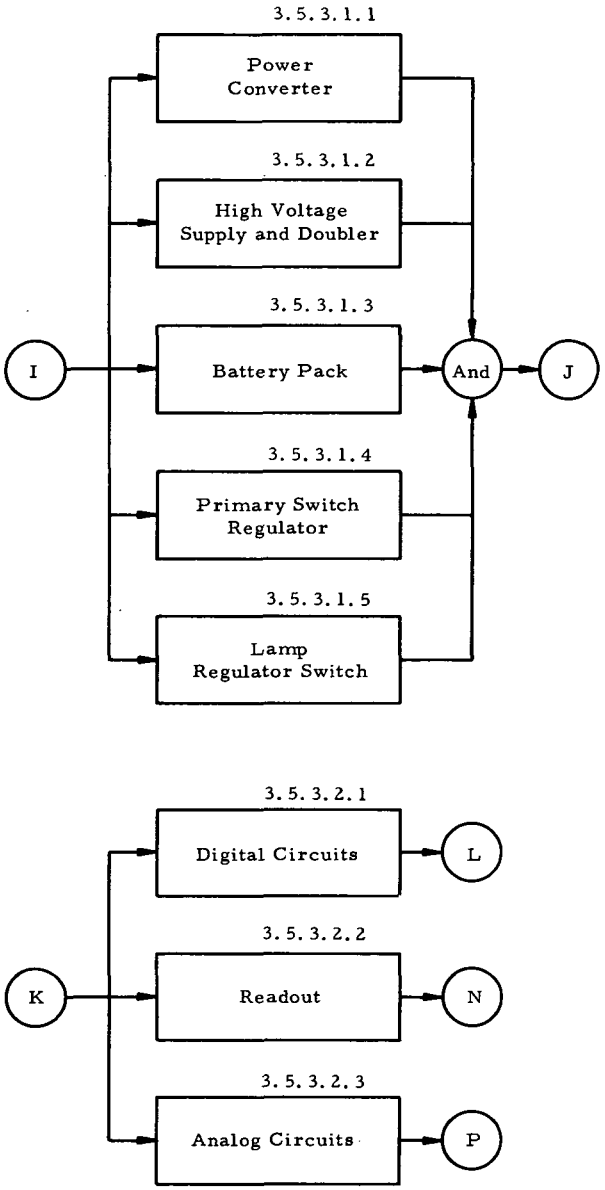


FIGURE P-1. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS FUNCTIONAL BLOCK DIAGRAM (Sheet 4 of 6)

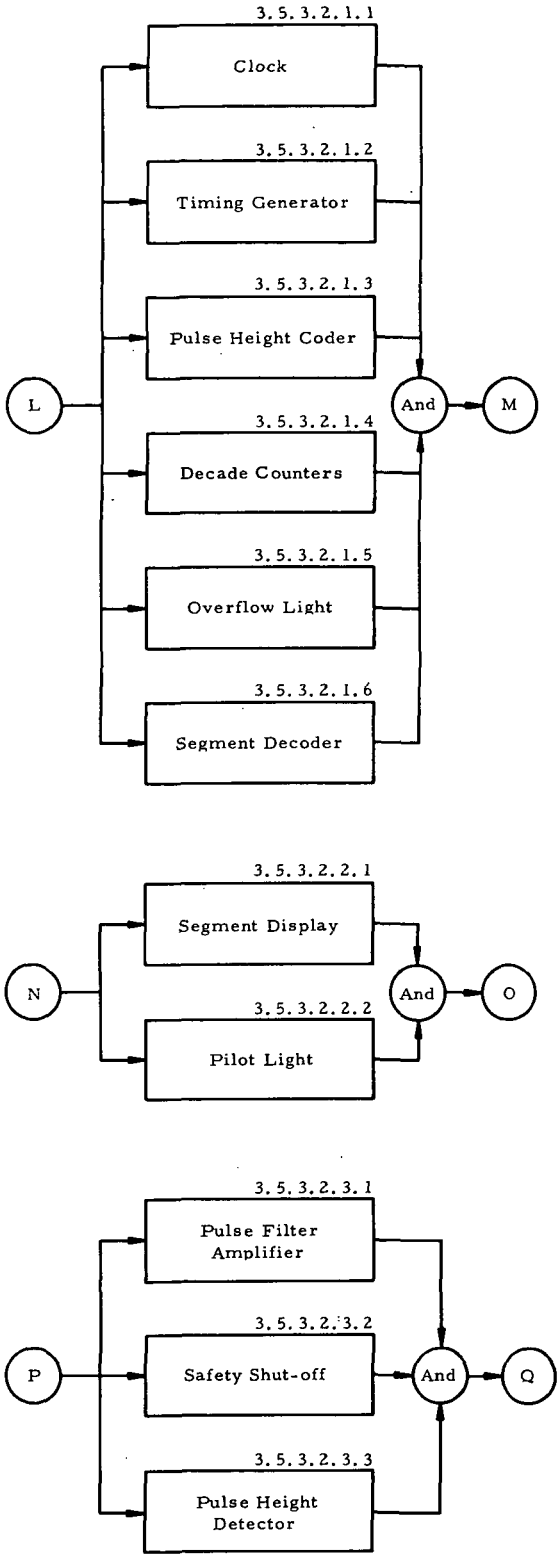


FIGURE P-1. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS FUNCTIONAL BLOCK DIAGRAM (Sheet 5 of 6)

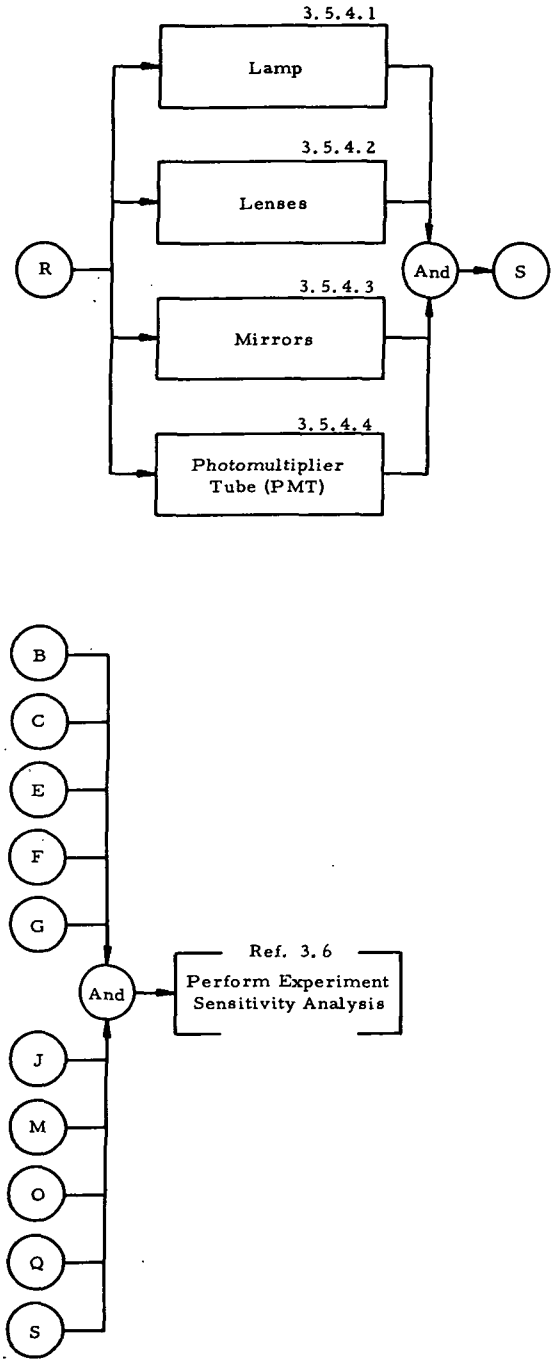
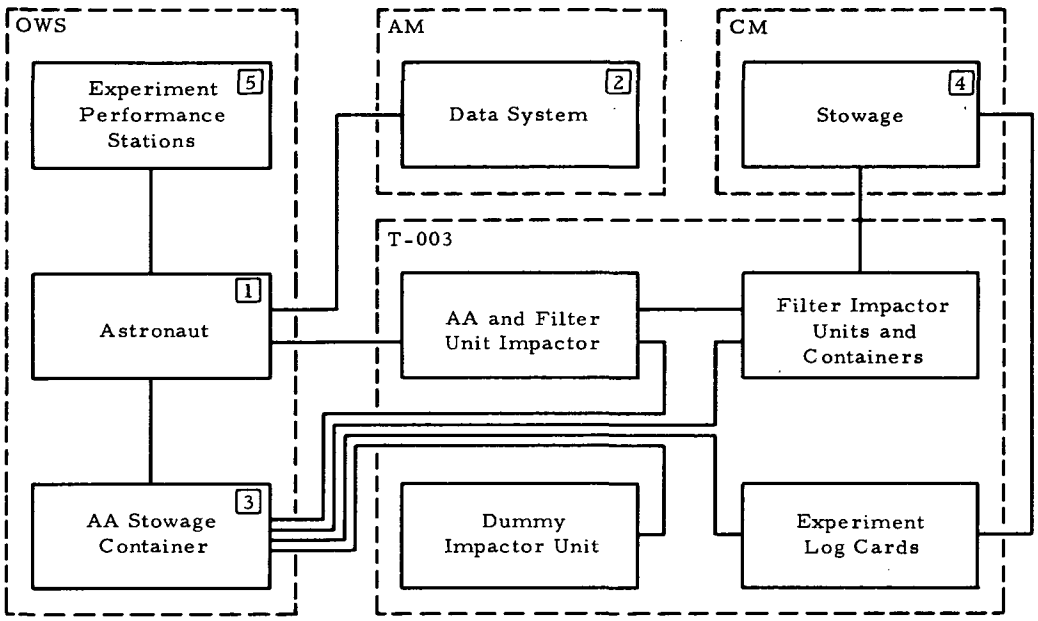


FIGURE P-1. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS FUNCTIONAL BLOCK DIAGRAM (Sheet 6 of 6)

SECTION II.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS INTERFACE BLOCK DIAGRAM



Code	Data Source	Remarks
1	Crew	There is an operability interface between the astronaut and the AA. The astronaut will hold the AA over the area where the measurements are to be taken. See Code 5 for additional information on crew station locations.
2	Crew	There is a communication interface between the astronaut and the AM data system. Crew comments are transmitted from different crew stations by the crewmember to the AM data recording system and then dumped to the ground.
3	Crew	There is a mechanical interface between the AA stowage container and each of the following: filter impactor units and containers, experiment log cards, dummy impactor unit, and AA. During lift-off, the above items are stowed in the AA stowage container, which is hard mounted to the OWS structure.
4	Crew	There is a mechanical interface between the CM stowage and each of the following: the filter impactor units, containers, and the experiment log cards. At the end of each mission the filter impactor unit and log cards are stowed in the CM for return to earth.
5	Crew	

Crew Station Designation	Sta. No.	General Position
CS-CM	≈1043.000 (CM)	-24.5 Y Axis
CS-D	≈684.458 (OWS)	Concentric with the X Axis
CS-E	≈350.663 (OWS)	Between Positions IV and I
CS-F	≈386.663 (OWS)	Between Positions I and II
CS-W	≈389.925 (OWS)	Between Positions II and III
CS-H	≈409.562 (OWS)	Between Positions II and III
Others	TBD by the astronaut	TBD by the astronaut

FIGURE P-2. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS INTERFACE BLOCK DIAGRAM AND DEFINITION

SECTION III.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS SYSTEMS DIAGRAM

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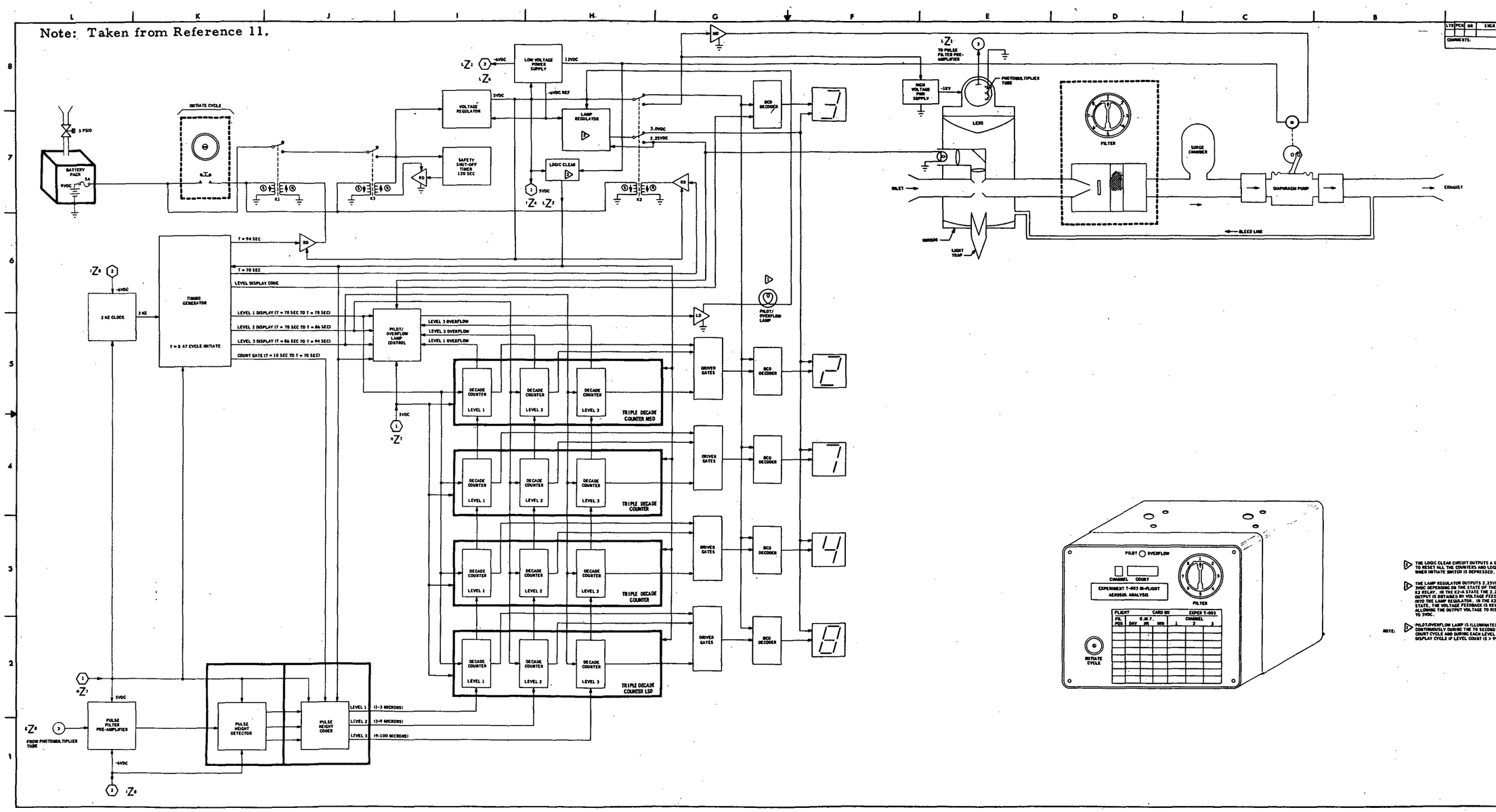
Note: Taken from Reference 11.



THE LOGIC CLEAR CIRCUIT OUTPUTS A SIGNAL TO RESET ALL THE COUNTERS AND LOGIC WHEN INITIATE SWITCH IS DEPRESSED.

THE LAMP REGULATOR OUTPUTS 2.25VDC OR 3VDC DEPENDING ON THE STATE OF THE K3 RELAY. IN THE K3-A STATE THE 2.25VDC OUTPUT IS OBTAINED BY VOLTAGE FEEDBACK INTO THE LAMP REGULATOR. IN THE K3-B STATE, THE VOLTAGE FEEDBACK IS REMOVED ALLOWING THE OUTPUT VOLTAGE TO RISE TO 3VDC.

NOTE:

PILOT/OVERFLOW LAMP IS ILLUMINATED CONTINUOUSLY DURING THE 70 SECOND COUNT CYCLE AND DURING EACH LEVEL DISPLAY CYCLE IF LEVEL COUNT IS > 9999.

FIGURE 3. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS SYSTEMS DIAGRAM

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SECTION IV.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS DATA REQUIREMENTS SUMMARY

TABLE P-II. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS DATA REQUIREMENTS SUMMARY

Measurement Name	Range and Dimension of Variables	Measurement Number	Telemetry Assignment Channel	Data Return	Data Time	Remarks
• Astronaut Voice Comments and Recording	N/A	N/A	N/A	Intermittent	All	
• OWS Temperature	TBS	TBS	TBS	Intermittent	All	
• OWS Relative Humidity	TBS	TBS	TBS	Intermittent	All	
• Experiment Log Cards	N/A	N/A	N/A	N/A	N/A	

SECTION V.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS DATA REQUEST FORMS

DATA REQUEST FORM Skylab Program	DRF Control No.	Date
	Exp/Sys No. ASTN-SD/OWS/EXP-069	Revision

Mission	Period of Interest	Op. Need Date	Rev Date
SL-2, 3, 4	POST-FLT		

Request Contact	Data Recipient	Date Req
Name Organization Phone	Name Mr. W. R. Bock Address S&E-ASTN-SDF Phone MSFC, Alabama 35812 205-453-3810	Qty

Reference Documents

MRD Content

Detailed Requirements:

Corollary Experiments Debriefing Data

Provide one copy of the crew debriefing transcripts pertaining to all corollary experiments operated during the entire mission

Comments & Explanations

Originator	Integrator
Name W. R. Bock Organization MSFC/S&E-ASTN-SDF Phone 205-453-3810 Signature [signature] Date 3-27-72	Name J. R. Riquelmy Organization S&E-ASTN-SDF Phone 205-453-3810 Signature [signature] Date 3-27-72
Request Aproval	**Implementing Agency**
Name Organization Phone Signature Date	Name Organization Phone Signature Date

MSFC - Form 65 (October 1970)

DATA REQUEST FORM

Skylab Program

	DRF Control No.		Date
	Exp/Sys No. ASTN-SD/SWS/EXP-070		Revision
Mission: SL-1/2, 3, 4	Period of Interest: FLT/MANNED	Op. Need Date	Rev Date

Request Contact	Data Recipient	Date Req
Name Organization Phone	Name: Mr. W. R. Bock Address: S&E-ASTN-SDF Phone: MSFC, Alabama 35812 205-453-3810	MCC + 72 hr Qty

Reference Document:

MRD Content

Detailed Requirements:

Crew Voice Transcripts

Provide on a daily basis, crew voice transcripts for each of the Skylab missions.

Comments & Explanation:

Originator	Integrator
Name: Mr. W. R. Bock Organization: MSFC/S&E-ASTN-SDF Phone: 205-453-3810 Signature / Date	Name: J. R. Riquelmy Organization: S&E-ASTN-SDF Phone: 205-453-3810 Signature / Date
Request Approval	**Implementing Agency**
Name Organization Phone Signature / Date	Name Organization Phone Signature / Date

DATA REQUEST FORM Skylab Program	DRF Control No.	Date
	Exp/Sys No. ASTN-SD/SWS/EXP-	Revision

Mission	Period of Interest	Op. Need Date	Rev Date
SL-1/2, 3, 4	FLT/ MANNED		

Request Contact	Data Recipient	Date Req
Name Organization Phone	Name W. R. Bock Address S&E-ASTN-SDF MSFC, Alabama 35812 Phone 205-453-3810	Qty

Reference Document:

MRD Content

Detailed Requirements:

Crew Voice Communications

Provide on a daily basis access to real time crew voice communications during all corollary experiment preparation, operation, and termination phases.

Comments & Explanation:

Originator	Integrator
Name W. R. Bock Organization MSFC/S&E-ASTN-SDF Phone 205-453-3810 Signature Date	Name J. R. Riquelmy Organization S&E-ASTN-SDF Phone 205-453-3810 Signature Date
Request Aproval	**Implementing Agency**
Name Organization Phone Signature Date	Name Organization Phone Signature Date

MSFC - Form 65 (October 1970)

DATA REQUEST FORM Skylab Program	DRF Control No.	Date
	Exp/Sys No. ASTN-SD/SWS/EXP-	Revision

Mission	Period of Interest	Op. Need Date	Rev Date
SL-1/2, 3, 4	POST-FLIGHT		

Request Contact	Data Recipient	Date Req
Name Organization Phone	Name W. R. Bock Address S&E-ASTN-SDF Phone MSFC, Alabama 35812 205-453-3810	Qty

Reference Document:

MRD Content

Detailed Requirements:

Experiment Logs

Provide one copy of each Corollary Experiment Log Book, when applicable, at the end of the Skylab mission.

Comments & Explanation:

Originator	Integrator
Name W. R. Bock Organization MSFC/S&E-ASTN-SDF Phone 205-453-3810 Signature Date	Name J. R. Riquelmy Organization S&E-ASTN-SDF Phone 205-453-3810 Signature Date
Request Aproval	**Implementing Agency**
Name Organization Phone Signature Date	Name Organization Phone Signature Date

MSFC - Form 65 (October 1970)

SECTION VI.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS ENGINEERING CHANGE REQUESTS

Engineering Change Requests for Experiment T-003 are N/A.

SECTION VII.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS EVALUATION SEQUENCE

TABLE P-III. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS EVALUATION SEQUENCE (Sheet 1 of 4)

Assignments

Mission:

- SL-1/SL-2, SL-3 and SL-4

Orbital Assembly (OA):

- OWS

Carrier:

- Located at CS-11 in the aft compartment of the OWS, at OWS Sta No. 350.663.

Conditions

Crew:

- The pilot (PLT) operates the AA.

Experiment:

- A measurement must be taken at CS-11 as soon as possible after OWS activation and every 8 ±2 hr thereafter, the duration of the flight.
- Measurements must be taken in the following locations no later than 8 days after OWS activation and every 10 days thereafter, throughout the duration of the flight. The locations are: CS-10, CS-1B, CS-11, CS-15, CS-16 and CS-12.

Ground Support:

- Prelaunch
  --Remove dummy filter unit and test battery pack from AA prior to SL-1 launch.
  --Install flight battery pack and SL-1/SL-2 filter impactor unit in AA prior to SL-1 launch.

Requirements

Functional Objectives:

- FO-1 through FO-4 are to be accomplished in each mission.

Experiment Evaluation Team - Key Personnel Locator

Name	Responsibility	Office Address, Symbol, and Telephone Number
Dr. W. Leavitt	Principal Investigator (PI)	Department of Transportation, Cambridge Massachusetts, 617-494-2608
Mr. W. Harriott	Experiment Developer (ED)	Department of Transportation, Cambridge, Massachusetts, 617-494-2608
Mr. Bill Jenkins	MSFC Experiment Manager (EM)	MSFC Bldg. 4201, PM-SL-DP, 205-453-3182
Mr. Walt Gillespie	S&E Integration Engineer (IE)	MSFC Bldg. 4610, CSE-AE, 205-453-2785
N/A	S&E Experiment Engineer (EE)	N/A
Mr. W. R. Bock	Technical Discipline Manager (TDM)	MSFC Bldg 4610, S&E-ASTN-SDF, 205-453-3811
Mr. K. S. Purushotham	Experiment Operations Engineer (EOE)	Teledyne Brown Engineering Company, Huntsville, Alabama, 205-532-1561
Mr. R. Calkin	Mission Operations Design Support (MODS)	Martin Marietta Corporation, Denver, Colorado, 303-794-5211, ext. 3147
Mr. George Gasper	Experiment Integration Engineer (EIE)	Martin Marietta Corporation, Denver, Colorado, 303-794-5252
Mr. Richard Schutheiss	Experiment Flight Controller (EFC)	MSC, Houston, Texas, 713-483-4616

TABLE P-III. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS EVALUATION SEQUENCE (Sheet 2 of 4)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P - 60 min GMT: TBD for SL-1/SL-2, SL-3 and SL-4 is at the option of the PLT.		Experiment Evaluation Team manned and available. Contact Experiment T-003, Technical Discipline Manager, S&E-ASTN-SD: HOSC Telephone No. TBD, Astronautics Laboratory Telephone No. 205-453-3810.				
		Reference: Skylab Flight Plan, SL-1/SL-2, SL-3 and SL-4, Summary Timeline, MSC-03625, latest revision, and Skylab Operations Handbook, Volume II: Experiment Operational Procedures, MSC.				
P - 10 min		Commence experiment preparation (ground action).				
P 1.0		Determine experiment status (PLT will alert the ground personnel).				
P = 0 min		Commence experiment preparation (flight action).				
P 2.0	PLT	Remove the AA from the stowage container.				
P 3.0	PLT	Transport the instrument to the experiment performance location.				
P 4.0	PLT	Set the filter impactor to the required position.			P40A1 P40B1	
P 5.0	PLT	Record GMT and the filter position on log card.				

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**TP - Test Pilot (Commander)
OBS - Observer (Science Pilot)
PLT - Pilot
ALL - TP/OBS/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE P-III. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS EVALUATION SEQUENCE (Sheet 3 of 4)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.0	PLT	Commence experiment operation.				
O 1.1	PLT	Initiate the cycle button and hold the instrument in position for 70 sec.			O11A1 O11B1	
O 1.2	PLT	Record channel No. 1. Record channel No. 2. Record channel No. 3. Note: The measurements are to be taken at 7 designated stations of the OWS and 1 designated station of the CM. The procedures described above are typical for all measurement stations.			O12A1 O12A2	

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**TP - Test Pilot (Commander)
OBS - Observer (Science Pilot)
PLT - Pilot
ALL - TP/OBS/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE P-III. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS EVALUATION SEQUENCE (Sheet 4 of 4)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
T 1.0	PLT	Commence experiment termination.				
T 1.1	PLT	Remove filter impactor unit from the AA.			T11A1	
T 1.2	PLT	Insert the next designated filter impactor unit into the AA.			T12A1	
T 1.3	PLT	Insert the used filter impactor unit in the empty return container.				
T 1.4	PLT	Stow the AA.				
T 1.5	PLT	Stow used filter impactor unit and experiment log cards in CM stowage locker.				

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**TP - Test Pilot (Commander)
OBS - Observer (Science Pilot)
PLT - Pilot
ALL - TP/OBS/PLT

MSFC - One Time Form 17-1 (March 1972)

SECTION VIII.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS MALFUNCTION AND CONTINGENCY PLAN OUTLINE

TABLE P-IV. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 4.0	Set the filter impactor to the required position.	P40A Unable to index the filter impactor to the desired position.	P40A1 Remove the filter from the AA and check for bent guide pin. If satisfactory, reinstall the filter and continue the experiment.	
		P40B Unable to hold the filter impactor securely in one position.	P40B1 Operating crewman can use his fingers to hold the filter impactor in one position during the sampling period.	

P

ASTN-OT-7 (Feb. 72)

TABLE P-V. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.1	Initiate cycle button and hold the instrument in position for 70 sec.	O11A Switch fails open. No indication that the experiment is operating.	O11A1 Recycle the switch. If there is no change in the status, terminate the experiment.	
		O11B Switch stays closed. The experiment will operate continuously instead of automatically shutting itself off at the end of 90 sec.	O11B1 Try to release the switch by tapping the instrument. If this fails, remove the rear cover of the instrument, disconnect the batteries, and terminate experiment.	
O 1,2	Record channel 1. Record channel 2. Record channel 3.	O12A No indication on digital display for any of the three channels. Possible battery failure or failure of electronics.	O12A1 The experiment may be continued under degraded mode if the pump is operating. If no power is available, the experiment will be terminated. O12A2 If the displays appear on one or two channels only, the experiment will be continued.	

TABLE P-VI. EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
T 1.1	Remove the filter impactor unit from the AA.	T11A Unable to remove the filter impactor.	T11A1 Use the portable astronaut tool kit to remove the filter. If the filter impactor cannot be removed, terminate the experiment.	Consideration should be given to returning the analyzer to earth for repairing.
T 1.2	Insert the next designated filter impactor unit into the AA.	T12A Unable to install filter impactor unit.	T12A1 Inspect the filter and remove any obstructions. If guide pin is bent, discard the filter and try to insert new filter. If either of the above fails, terminate the experiment.	

T

SECTION IX.

EXPERIMENT T-003, IN-FLIGHT AEROSOL ANALYSIS MALFUNCTION ANALYSES

The material contained in this section is an excerpt from Reference 12.

7. INFLIGHT AEROSOL ANALYSIS, T003

The primary functions of T003 that have been identified as requiring analysis are presented in Table 7.1.

All displays are on the instrument and available only to the crewman operating the unit. Corrective action is extremely limited as no repair or replacement parts are carried and the working parts of the unit are not accessible to the crew. Failure of the battery, pump, or motor will be cause for termination of experiment operation. Other failures will cause degraded data but the option of continuing the experiment is available and feasible.

Table 7.1 Operational Functions and Malfunction Analysis Items, T003

Operational Function	Sub-Function	Malfunction Analysis Item
7.1 Provide Particle Count	7.1.1 Provide Optics	(Failure of lamp, PMT, or HV Reg.)
	7.1.2 Provide Electronics	7.1.2.1 Analog Circuit Failure 7.1.2.2 Loss of Pilot-Overflow Function 7.1.2.3 Loss of Digital Display Function
	7.1.3 Provide Pneumatics	7.1.3.1 Pump or Motor Failure 7.1.3.2 Impeded Airflow
	7.1.4 Provide Electrical Power	7.1.4.1 Battery Failure or INITIATE CYCLE sw Contacts Fail Open 7.1.4.2 INITIATE CYCLE sw Contacts Fail Shorted
7.2 Provide Filtering and Collection	7.2.1 Provide Filter Insert Assembly	7.2.1.1 Failure to Remove (Insert) Unit 7.2.1.2 Failure to Index Unit to Desired Position

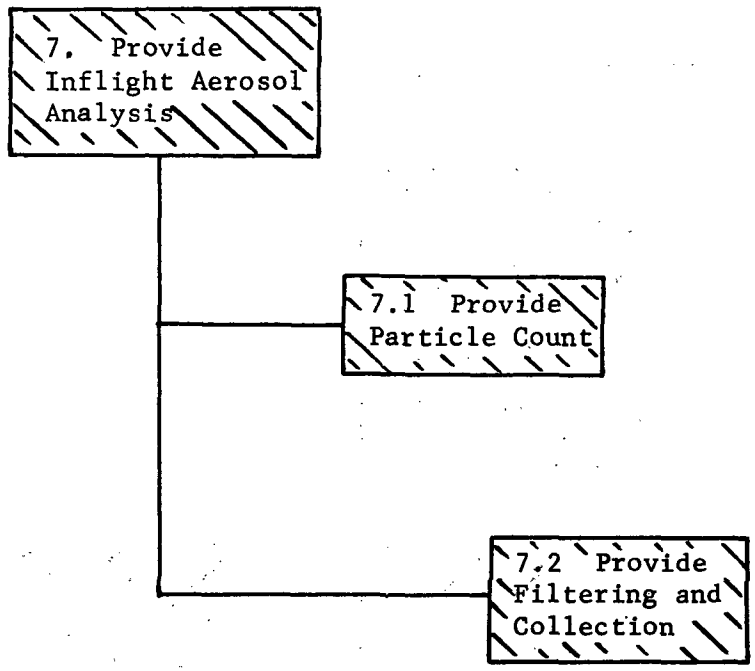

Figure 7.1 Functional Flow Diagram, Experiment T003

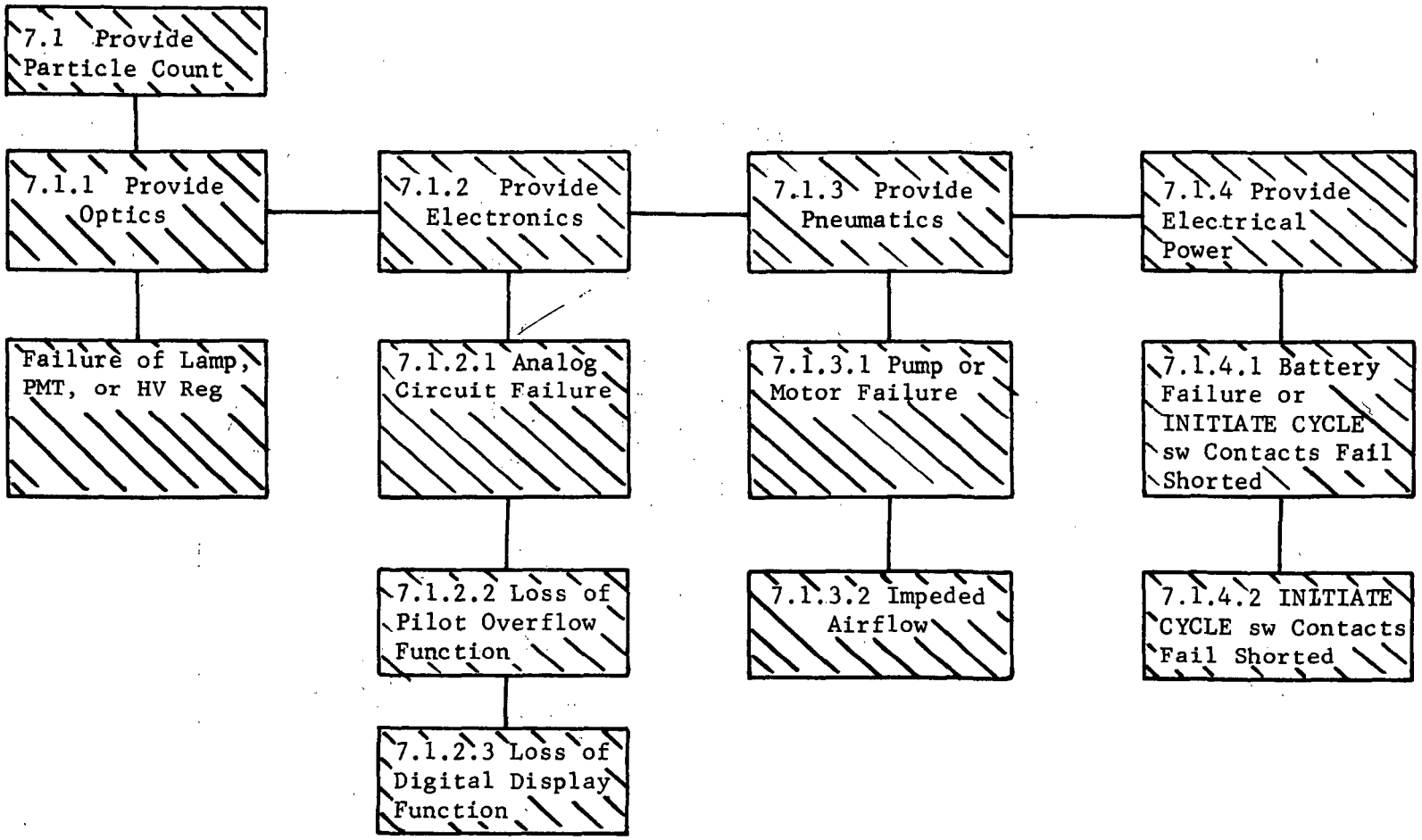

Figure 7.2 Malfunction Analysis Diagram, Particle Count, T003

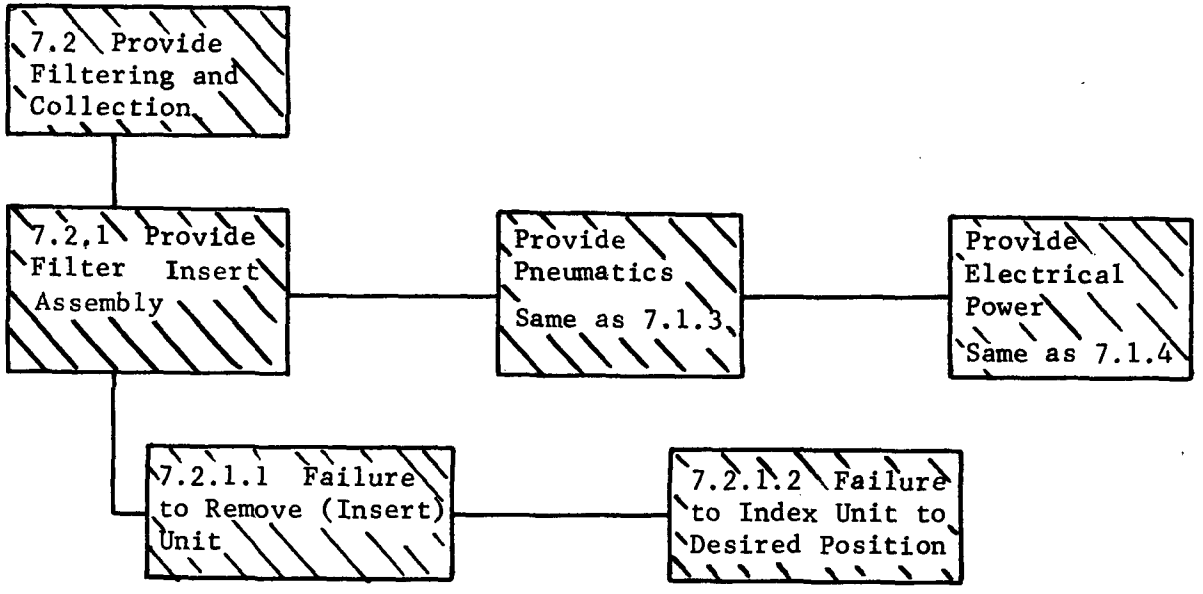

Figure 7.3 Malfunction Analysis Diagram, Filtering and Collection, T003

MALFUNCTION ANALYSIS CHART, T003

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
7.1 Provide Particle Count						
7.1.1 Provide Optics (Failure of Lamp, PMT, or HV Reg.)	Crew Observation, (U): COUNT ind 0000 on all three channels.	None	Mission: None Crew: Timeline effect.	Loss of particle count readout data.	None	Ground Action: None Crew Action: Phases D, F, H. 1. Continue experiment. Filter-impactor samples can still be collected. Note: For all failures of the Aerosol Analyzer, the ground should be advised and requested to decide whether to continue any experiment activity, and to consider the feasibility of returning the analyzer to the ground for repair/replacement for subsequent missions.
7.1.2 Provide Electronics						Ground Action: None Crew Action: Phases D, F, H.
7.1.2.1 Analog Circuit Failure (Pulse Filter Pre-Amplifier, Pulse Height Detector, Pulse Height Coder, Decode Counters, Driver Gates, BCD Decoders, etc.)	Crew Observation, (U): COUNT ind, no display on channel(s) 1 or 2 or 3 or any combination, or no CHANNEL ind.	None	Mission: None Crew: Timeline effect.	Channel 1 Failure: Loss of particle count for particles from 1 to 3 micron size. Channel 2 Failure: Loss of particle count for particles from 3 to 9 micron size. Channel 3 Failure: Loss of particle count for particles from 9 to 100 micron size.	None	1. Continue experiment. (See Note 7.1.1)

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T003

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
7.1.2.2 Loss of Pilot Overflow Function.	Crew Observation, (U): PILOT OVERFLOW lt does not light during the 70 sec period following initiation of sampling cycle. COUNT ind displays data after 70 sec.	Crew Observation, (U): Presence of noise/vibration during 70 sec sampling period.	Mission: None Crew: None	Loss of indication that experiment is operating properly. Cannot determine if an overflow condition has occurred: Displayed data may be invalid.	None	1. Continue experiment. (See Note 7.1.1)
7.1.2.3 Loss of Digital Display Function.	Crew Observation, (U): COUNT ind: Loss of one or more digits or bars of a digit of the display.	None	Mission: None Crew: Timeline effect.	Part or all of particle count data will be lost. Loss will be greatest if the most significant digit display fails and to a lesser extent for loss of other display digits or bars thereof.	None	1. Continue experiment. (See Note 7.1.1)
7.1.3 Provide Pneumatics						Ground Action: None Crew Action: Phases D, F, H.
7.1.3.1 Pump or Motor Failure	Crew Observation, (U): No airflow at aerosol analyzer inlet or outlet ports in conjunction with normal operation of PILOT OVERFLOW lt and COUNT ind after 70 sec.	Crew Observation, (U): Absence of noise/vibration indicative of pump/ motor operation. (Inconclusive in absence of primary indication.)	Mission: None Crew: Timeline effect.	Air cannot be drawn through optics or impinge on filter impactor. No data can be obtained. Loss of experiment.	None	1. Terminate experiment. (See Note 7.1.1)
7.1.3.2 Impeded Airflow	Crew Observation, (U): Abnormally low reading of particle count (based on previous experience)	None	Mission: None Crew: None	Particle count data will be invalid.		1. Inspect inlet and outlet ports for physical obstruction and remove, and 2. Continue experiment. (See Note 7.1.1)

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T003

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
7.2 Provide Filtering and Collection.						
7.2.1 Provide Filter Insert Assembly						Ground Action: None Crew Action: Phases D, F, H.
7.2.1.1 Failure to Remove (Insert) Unit.	Crew Observation, (U): Abnormal physical force required to remove (insert) unit.	None	Mission: None Crew: Timeline effect.	Loss of particle collection data.	None	1. Remove any obstructions, and 2. Use vise-grip or pliers to force removal/insertion, and 3. Continue experiment. (See Note 7.1.1)
7.2.1.2 Failure to Index Unit to Desired Position.	Crew Observation, (U): Unit will not remain at position selected by index arrow marking.	None	Mission: None Crew: None	Loss of particle collection data for selected position. Unit may drift from position and collect data on random impactor discs.	None	1. Hold unit at selected position during 70 sec sampling period (tape, fingers, etc.), and 2. Continue experiment. (See Note 7.1.1)

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T003

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
7.1.4 Provide Electrical Power						Ground Action: None Crew Action: Phases D, F, H.
7.1.4.1 Battery Failure or INITIATE CYCLE sw Contacts Fail Open	Crew Observation, (U): No airflow at inlet or outlet ports, and PILOT OVERFLOW lt does not light during sampling cycle, and COUNT ind: no digits displayed.	Same as 7.1.3	Mission: None Crew: Timeline effect.	Precludes operation of all functions of experiment. Loss of experiment.	None	1. Recycle INITIATE CYCLE sw, and 2. Terminate experiment. Note: Battery is replaceable. (See Note 7.1.1)
7.1.4.2 INITIATE CYCLE Sw Contacts Fail Shorted	Crew Observation, (U): Experiment does not shut off after 94 sec cycle. Continues to cycle each 94 secs until battery depletion.	None	Mission: None Crew: Timeline effect.	Unit will continue to operate until battery is depleted. Data will be obtained but not at the time and in the planned manner. (Expected battery life is 9.625 hours of operation.)	None	1. Recycle INITIATE CYCLE sw, and 2. a. Open battery compartment using flat bladed screwdriver, and b. Remove connector from battery, and c. Close and secure battery compartment and stow T003, and d. Open battery compartment, and e. Reconnect battery for subsequent operation. CAUTION: This action violates flight safety criteria re:mating or demating powered connectors in orbit.

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

SECTION X. CONCLUSIONS AND RECOMMENDATIONS

An analysis of Experiment T-003 revealed that the P_f of the AA hardware is minimum. If the AA were to fail it would result in category III failure.

Based on our understanding of relative humidity contained in the OA, there is no environment and experiment interface problem. However, it is suspected that in certain areas, where the measurements are to be taken, there may not be sufficient circulation or mixing of the atmosphere. Temperature variations in such areas cause the humidity to increase. Humidity higher than 95 percent affects the AA optics. The astronauts should be made aware of such situations before performing the experiment.

There is a possibility that radiation could affect the optics and mirror system of the AA. Radiation could darken the lenses or reflective surfaces of the optics. This could bias the photon emission output, and result in erroneous counting of the sample particles. Further investigation needs to be conducted in this area.

The AA is a very small unit and is highly sophisticated. In the event the unit fails, consideration should be given to returning this equipment to the earth for investigation or maintenance.

REFERENCES

1. Skylab Flight Plan. Skylab Missions SL-1/SL-2, SL-3 and SL-4. MSC Document No. TBD, Manned Spacecraft Center, Houston, Texas, May 1, 1972.

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3. Mission Requirement Document. Vol. II: Second Skylab Mission SL-3, I-MRD-001D, Manned Spacecraft Center, Houston, Texas, August 1, 1971.

4. Mission Requirement Document. Vol. III: Third Skylab Mission SL-4, 1-MRD-001-D, Manned Spacecraft Center, Houston, Texas, November 1, 1971.

5. Experiment Requirements Document for Experiment T-003, In-flight Aerosol Analysis. SE-01-024-2H, CCBD No. 800-70-0048, Marshall Space Flight Center, Huntsville, Alabama, January 12, 1972.

6. Skylab Operations Handbook. Vol. I: Experiment Descriptions, MSC-000924, Manned Spacecraft Center, Houston, Texas, November 19, 1971.

7. Skylab Program Directive No. 43B Operation Directive (Draft). NASA Office of Manned Space Flight, Washington, D.C., February 1972.

8. OWS Reliability Report. Vol. X: Failure Mode Effect and Criticality Analysis for Experiment Systems. MDC-GO-433-A, McDonnell Douglas Aircraft Company, Western Division, Huntington Beach, California, December 1, 1971.

9. End Item Specification Parts 1 and 2, Parts and Material List, FMEA, Non-metalic Material List for In-flight Aerosol Analysis (Experiment T-003), Rev. II. DOT-TSC-NASA-71-1, Department of Transportation, Transportation System Center, Cambridge, Massachusetts, July 12, 1971.

REFERENCES (Concluded)

10. Electronic Subsystem Final Design Documentation for Experiment T-003, Report No. 5354, Department of Transportation, Transportation System Center, Cambridge, Massachusetts, November 1970.

11. Skylab Experiments System Handbook. MSC Document No. TBD, Manned Spacecraft Center, Houston, Texas, September 1, 1971.

12. Wilcoxson, C. B., et al: Mission Operations Design Support, Volume III. - OWS Experiments Malfunction Analyses, Rev. A, ED-2002-1244, Martin Marietta Corporation, Denver, Colorado, May 12, 1972.